Electric school bus and infrastructure guidebook

Kentucky Clean Fuels Coalition

KENTUCKY CLEAN FUELS COALITION

KENTUCKY CLEAN FUELS COALITION

The Kentucky Clean Fuels Coalition was established in 1993 to provide the first alternative fuels resource for Kentucky educators, consumers and providers of alternative fuels/vehicles.

It is now a successful non-profit 501C3 self-supporting organization and a national leader in the clean fuels market.

The mission of the Kentucky Clean Fuels Coalition (KCFC) is to connect providers and consumers of fuels across Kentucky with the best information and education available about clean transportation technologies.

Operating Strategies and Objectives

- Build partnerships between providers and consumers of fuel.
- Raise awareness about the opportunities and benefits of using alternative fuels and advanced transportation technologies.
- Focus on incorporating alternative fuels and advanced transportation technologies
- Provide members and stakeholders with continuing education opportunities and reliable informational resources upon which they can base decisions.
- Commit to air quality and environmental stewardship.
- Provide a balanced source of information for developing partnerships and a realistic market approach to project implementation.
- Focus on incorporating alternative fuels and advanced transportation technologies into technician education.

KCFC Vision

Transforming Kentucky into a model area for the development and implementation of public policy that supports and encourages the development and use of alternative fuels and technologies for transportation purposes and to improve air quality, diminish dependence on foreign oil, and enrich the state economy by creating alternative fuel options that make it inviting for commercial carriers to conduct interstate commerce.

In addtion, this guidebook supports and ties into our efforts for Plug-In Kentucky.

Electric School Buses

Introduction

An electric school bus is a type of electric vehicle (EV). This means it is fueled by electricity rather than other fuel types such as gasoline. Unlike a hybrid vehicle, which combines battery power with an internal combustion engine, an electric school bus relies solely on electricity for power.

An electric school bus draws electricity from the power grid and stores it in a battery that can be recharged once the electricity has been used up. The electrically charged battery powers an electric motor in the bus. This is accomplished as the bus driver's foot presses on the accelerator, the battery powers the motor, which powers the gears that rotate the bus's tires. In a traditional bus, a motor works along with an alternator, but an electric motor in an EV has the double function of acting as an alternator and motor. This is possible because the voltage of an AC signal can easily be increased or decreased.

Electric school buses are a newer alternative to more traditional buses, but they are becoming a popular option for cities, private transportation companies and school districts that want to take advantage of EV technology. This guidebook will answer your basic questions about EV buses and charging infrastructure and guide you to other available information.

Benefits of Driving EV School Buses

- **Requires significantly less maintenance** than conventional fueled buses. When performing maintenance on an electric bus, engine oil changes, engine air filter changes, smog testing, replacing coils or spark plus, and transmission maintenance.
- **Reduces greenhouse gases** because EV school buses produce zero emissions at the tailpipe. This will improve the air we breathe and the health of our kids, who can be more susceptible to the negative effects of pollution.
- **No Noise Operation** due to electric school buses operating more quietly than traditional buses with internal combustion engines. School bus drivers in an electric bus are better able to hear what is going on in the seats behind them. This can help drivers feel more of a sense of control and can increase the level of accountability among students on board. A quieter operation can also help drivers maintain better focus on the road.
- **Cost Savings** due to minimizing maintenance costs and eliminating fuel costs. These cost savings can add up to 80% savings on energy costs and up to 60% on maintenance costs. In addition, there are electric school bus rebates available depending on the type, make, and model of electric school bus, and the state you reside in.

Charging Information

Electric Infrastructure

When converting to an electric school bus operation, having access to a facility with charging stations are crucial. A typical facility will have:

Transformers: Electric devices that change electricity from one level or voltage to another.

Access to an electric grid: An interconnected network for delivering electricity that will go to charging stations and subsequently to the EV.

Charging meter: A device that records the amount of power flowing through a circuit.

Charging stations: A physical station where EV school buses are parked and charged.

DID YOU KNOW?

Replacing one diesel bus with an electric bus can reduce greenhouse gas emissions by 54,000 pounds per year!

Charging Stations

EV charging infrastructure is a necessary component of a successful EV market. There are three levels of charging equipment available on the market today, Level 1, Level 2 and DC fast charging. The main difference is how quickly they can charge your bus, and their power requirements at your facility. Charging time depends on the type of charger installed. For vehicle range and charging compatibility, please see the manufacturer instructions.

Level 1: EVs can be plugged into a standard 120-volt outlet. One hour of charging can provide 2 to 5 miles of range. This is the slowest charging set up.

AC Level 2: Level 2 charging units require a 240-volt outlet. These chargers are the most common type of public electric vehicle supply equipment. One hour of charging can provide 10 to 20 miles of electric range, but to fully charge it will take approximately 6 to 8 hours to fully charge. Most buses charge overnight.

Direct Current (DC) Fast Chargers: DC charging units are often used for public charging stations, and it is the fastest charging technology available on the market today. Medium-powered DC fast charger will take approximately 4 to 6 hours to fully charge. This can be done overnight or between morning and afternoon routes. Higher-powered DC fast chargers may be able to fully charge in as little as two hours.

Installation Costs

Cost factors are influenced by required electrical work, trenching or boring, permitting, inspection, labor rates, and ADA requirements.

These factors lead to highly variable costs associated with installing EVSE. Utilizing best practices for choosing EVSE types, quantities, and locations will help minimize the financial impact of buying and installing EVSE. Ballpark cost ranges for EVSE units and installation are shown below.

Ballpark EVSE Unit and Installation Costs

EVSE Type	EVSE Unit* Cost Range (single port)	Average Installation Cost (per unit)	Installation Cost Range (per unit)
Level 1	$300-$1,500	not available	$0-$3,000** *Source: Industry Interviews*
Level 2	$400-$6,500	-$3,000 *EV Project (INL 2015b)*	$600-$12,700 *EV Project (INL 2015b)*
DCFC	$10,000-$40,000	-$21,000 *EV Project (INL 2015d)*	$4,000-$51,000 *EV Project (INL 2015d) and (OUC 2014)*

Level 1 Chargers

Level 1 units can range in cost from **$300-$1,500**. The lowest priced unit is a simple plug-in cordset A hardwired Level 1 pedestal unit with access control and cable management could cost closer to $1,500.

This wall-mounted Level 1 charger (left).

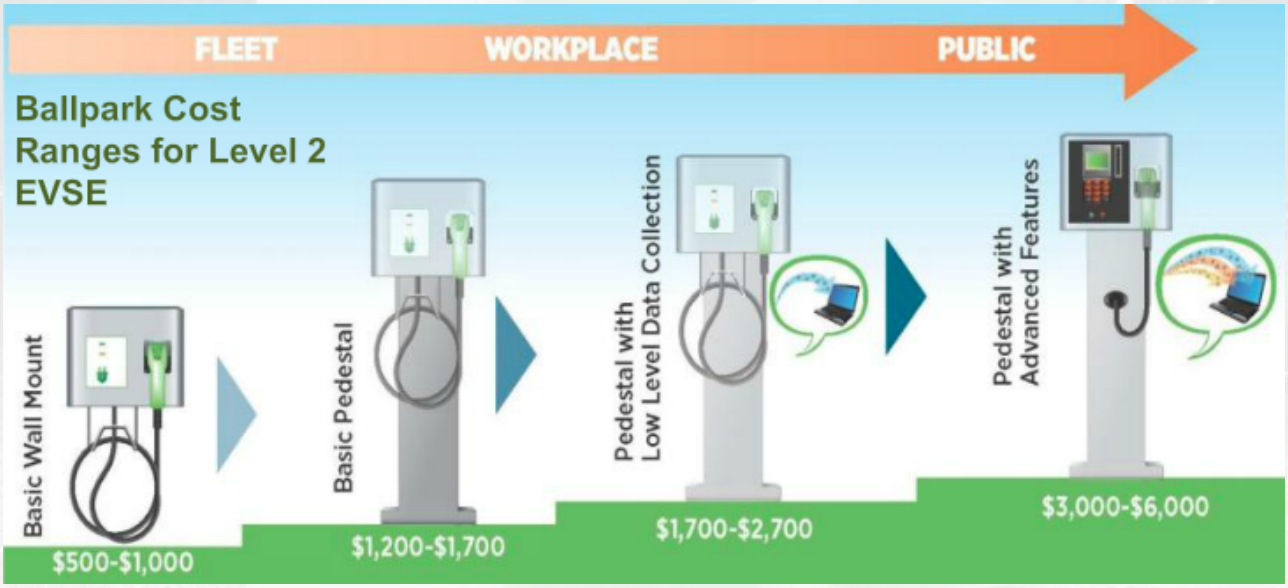
Every EV comes with a Level 1 charging cord that can be plugged into a standard 120-volt outlet. (right)

C

Level 2 Chargers

Single-port Level 2 units are available spanning a **$400-$6,500** cost range depending on included features. While there is no standard EVSE unit for the fleet, workplace, or public sites, the graphic below illustrates potential costs for Level 2 EVSE units with different tiers of additional features.

The pictured example is meant only to show how the cost of an EVSE unit may change based on the mounting system and selected features.



DC Chargers

DC charging units can range in cost from **$10,000** for a low-power, low-amperage, single-port unit with no display or networking components to **$40,000** for a high-power, high-amperage system that enables multiple vehicles to charge at once along with various special features.

More Charging Information

Network Charging Stations

Some stations are connected to a network that allows them to be monitored and managed using an online software platform. This can allow you to monitor the state of charge, alert you to station malfunctions, and provide managed charging.

Managed Charging allows you to minimize your electricity demand charges by scheduling your vehicles to charge in off-peak hours when loads are low such as overnight. This is done to manage charging costs and to reduce strain on the electrical grid. Networked stations are typically more expensive than non-networked stations.

Vehicle to Grid (V2G) technologies are relatively new and enable an electric school bus to partially discharge its battery to the grid while it sits idle and connected to a charger. Strategic timing of battery discharge could save money for the utility and still allow for a fully charged vehicle when needed, while potentially providing utility financial incentives to the fleet to help offset the cost of the electric bus.

Planning for Charging Stations at Your Facility

Any fleet considering a potential ESB project should first reach out to their local electricity provider/utility. This will help you understand the electricity usage required for your electric school bus and help determine if any infrastructure updates will be needed. Meeting with your utility early in the process is also one of the best ways to ensure the cost-effective and timely installation of your charging equipment.

Charger installation costs vary widely, two primary considerations are:

The distance from the power source to the charging station: Costs associated with connecting a charging station to the power source can account for 40% or more of the installation cost. If possible, minimize your installation costs by installing the station as close as possible to an existing power source that has sufficient capacity to avoid service upgrades. Longer distances between the charging station location and power source increase costs by requiring more electric circuit components and conduit-runs, as well as trenching or linear drilling costs for underground conduit.

Whether the charging station is mounted to an existing wall, or installed as a free-standing unit: Wall mounted charging stations are generally less expensive because they don't require a free-standing pedestal (or a concrete pad) or trenching to connect them to a power source. Whether wall-mount units can work for a school bus depends on the location and position of bus parking relative to the building. Placement of the charging station is also dependent on whether your buses pull forward or back into their parking locations, and whether the charging port on your ESBs will be located on the front or the back of the vehicle, to ensure adequate cord length and minimize cord tripping/damage hazards.

Photograph by [illegible] on Pixabay

Electric School Bus Options

Thomas Built Buses

The Saf-T-Liner C2 Jouley electric bus runs emissions-free, reduces noise pollution, uses no fossil fuels, and helps you save on operating costs. This includes specialized battery packaging for increased safety and drives up to 65 mph. This electric school bus accelerates from 0-60 mph in 45 seconds, has up to 138-mile operating range, built with up to 220 kWh power, and charges in 2-3 hours at a DC charging station.

Please see below for the Saf-T-Liner C2 Jouley vehicle specifications.

SAF-T-LINER® C2 JOULEY ELECTRIC SCHOOL BUS
POWERED BY PROTERRA® TECHNOLOGY

	Description	Value
VEHICLE SPECIFICATIONS		
Total energy	kWh	220
Operating efficiency*	kWh/mile	1.474
	MPGe	24.6
Range*	Nominal range in miles: total energy/ efficiency	Up to 149
	Operating range in miles: usable energy**/ efficiency	Up to 134
Top speed	mph	65
Acceleration	0-60 mph at GVW, seconds	49
Horsepower		295 peak, 170 continuous
Regen braking power		220 peak, 107 continuous
Motor		Proterra® ProDrive drivetrain; single 220kW permanent magnet drive motor
Transmission gearbox		Proterra 2-speed auto shift EV gearbox
Battery thermal management system		Liquid cooled
Battery pack enclosure		Ruggedized 10mm thick aluminum
Braking System		Regenerative braking, air disk brakes
Startability	grade	19%
CHARGING SPECIFICATIONS		
Type		Plug-in, DC fast charging
Standard		J1772 CCS Type-1
Charge power		up to 60 kW
Charging time (empty to full)		~ 3 hours with 60kW charger
WARRANTY		
Battery capacity		8 years / 175,000 miles / 200,000 kWh of gross discharge throughput per pack
Battery materials & workmanship		8 years / unlimited miles
Drivetrain		5 years / 100,000 miles
Extended warranty for battery & drivetrain available		up to 10 years

* will vary with route conditions, weather, vehicle configuration and driver behavior.
**all vehicle batteries must be limited to useable capacity, to decrease degredation and optimize longevity

Thomas BUILT BUSES
Because every mile matters.℠

PROTERRA POWERED

Lion Electric Company

The Lion Electric Co. is an innovative manufacturer of zero-emission vehicles. We think, design and manufacture all-electric school buses, midi/minibus for special needs or urban transit as well as urban trucks. Lion positions itself as a leading OEM in transportation electrification in North America. We design, manufacture and assemble all components of our vehicles: chassis, battery packs, cabin and powertrain.

Always actively seeking new technologies, Lion vehicles have unique features that are specifically adapted to its users and their everyday needs. We believe that transitioning to all-electric vehicles will lead to major improvements in our society, environment and overall quality of life.

Pictured to the right is the LionC all-electric school bus specifications.

Technical Specifications

WEIGHT & DIMENSIONS	
Vehicle length	473 in
Vehicle width	96 – 102 in
Vehicle height	122 in
Wheelbase	256 – 278 in
Gross Vehicle Weight Rating (G.V.W.R)	Up to 33,000 lb
Capacity	Up to 77 passengers
ELECTRIC POWERTRAIN	
Top Speed	60 mph
Maximum Power	250 kW • 335 HP
Maximum Torque	2,500 NM • 1,800 ft-lb
Range	100 – 125 – 155 miles
Battery Capacity	126 – 168 – 210 kWh
Motor & Inverter	SUMO-MD • Dana/TM4
Transmission	Direct Drive No Transmission
Charging Type	Level II (AC) - J1772 & Level III (DC) – CCS-Combo
Level II - Charging Time	
19,2 kW	6,5 – 11 hours
Level III - Charging Time	
24 kW 50 kW	5 - 9 hours 2,5 - 4,25 hours
CHASSIS	
Front axle	Up to 12,000 lb
Rear axle	Up to 21,000 lb
Suspension Standard Optional	 Spring suspension Rear air ride
Braking Standard Optional	 Hydraulic disc brakes Air discs

thelionelectric.com

IC BUS Electric CE Series School Bus

A zero-emissions school bus option with a lower total cost of ownership and user-friendly options and features, the Electric CE Series was engineered from the tires up to withstand the rigors of daily use and arrive at every destination on time, every time.

Please see below for the Electric CE Series vehicle specifications.

SPECIFICATIONS

GVWR
- 31,000 or 33,000 lbs.

Capacity
- 29 – 72 passengers

Wheelbase Options
- 217" or 276"

Single Rear Axle (4X2)
- Dana Spicer: 21,000 or 23,000 lbs.

Front Axle
- Meritor: 10,000 lbs.

Frame
- Heat treated alloy steel (120,000 PSI)

Front Suspension
- Parabolic taper-leaf: 10,000 lbs.

Rear Suspension
- International® Ride Optimized Suspension (IROS) Air, 21,000 or 23,000

Electrical System
- Battery System: Enersys Odyssey 12V 2300CCA

Brakes
- Air disc brakes with ESC, ATC and ABS

Motor
- 650 volt, 3-phase permanent magnet motor

Fuel Tank
- Optional 15 gallon tank – left side, outside frame rail for fuel fired heater

Exterior
- Standard crossing control gate

Interior
- 78" interior headroom
- Lighted steering-wheel mounted door control and eight-way light switches
- Available cruise control
- Optional factory-installed IC Air
- Entrance door stepwell – 14 ga steel, formed treads, Naviflex™ finish – standard
- Standard Leave No Student Behind®

Rear Axle Ratio
- 5.57 or 6.83

Powertrain Batteries
- 105, 210 or 315 kWh

Luggage Compartments
- Right Rear Side, 79" x 20" x 18"

Rated Horsepower
- Approx. 335 hp

Camera System
- Optional IC Bus® Full View Camera Technology™ by Rosco

Fasteners
- Optional stainless steel mounting fasteners for exterior lights and mirrors

Lights
- LED interior and exterior

Floor Covering
- Koroseal; body length

Tires
- Hankook 11 R22.5 front and rear

Note: The information and conclusions contained herein are believed to be correct at time of publication, but do not necessarily apply to similar vehicles with different specifications or with production dates after the production of this publication. Vehicles with different specifications or later dates of production may yield different results. Vehicle specifications are subject to change without notice.

BAD 21001 8/2021

Rebates for Electric School Buses

If you are interested in purchasing electric school buses for your school or fleet, please check out the following resources below.

2021 American Rescue Plan (ARP) Electric School Bus Rebates | US EPA: The U.S. Environmental and Protection Agency has released an updated website specific to the 2021 American Rescue Plan Electric School Bus Rebate Program. EPA will fund $7 million in electric school bus rebates in underserved communities under this program and it will run concurrent to the annual DERA program rebates. This will fund $300k per EV bus with a maximum of 4 buses awarded per applicant. Funding is available for school districts as well as contractors. The website is meant to give you advance notice to the opportunity and details as well as relevant documents, information, dates, and deadlines will be updated as they become available. Please visit the link below for more information. https://www.epa.gov/dera/2021-american-rescue-plan-arp-electric-school-bus-rebates

KENTUCKY CLEAN FUELS COALITION

For More Information:

www.kentuckycleanfuels.org/

facebook.com/kycleanfuels/

twitter.com/kycleanfuels